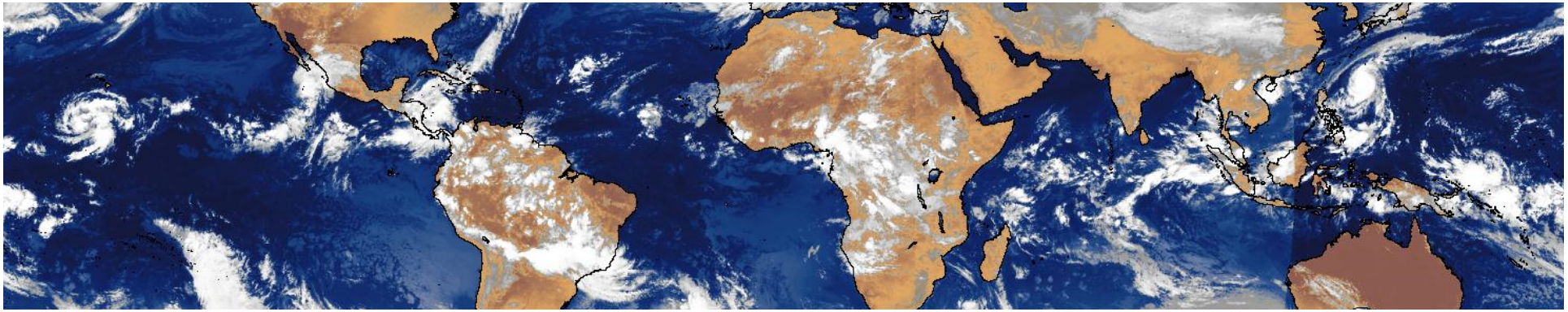
The Megha-Tropiques Mission



October 20th, 2009 0000Z courtesy www.satmos.meteo.fr

Rémy Roca (LMD)
and the French MT science team

The Megha-Tropiques mission
Outline of the talk

- Mission & Objectives
  - Payload
  - Orbit
- Activities on ERB in the MT team
  - Flux Algorithm developpement
  - Clear sky greenhouse effect and WV using CERES
  - GEO activity
- Cal/val plan
- Conclusions
  - IAO

The Megha-Tropiques mission
Overview

Indo-french mission realized by

The Indian Space Research Organisation and the

Centre National d'Etudes Spatiales

Dedicated to the

Water and energy cycle in the Tropics

Low inclination on the equator (20°);

865 km height

High repetetivity of the measurements

Launch foreseen in spring 2010

Expected duration: instruments 3 yr Plateform 5 yr fuel/operation

The Megha-Tropiques mission
Scientific objectives

Atmospheric energy budget in the intertropical zone and at system scale (radiation, latent heat, …)

Life cycle of Mesoscale Convective Complexes in the Tropics (over Oceans and Continents)

Monitoring and assimilation for Cyclones, Monsoons, Mesoscale Convective Systems forecasting. NRT capability.

Contribution to climate monitoring :

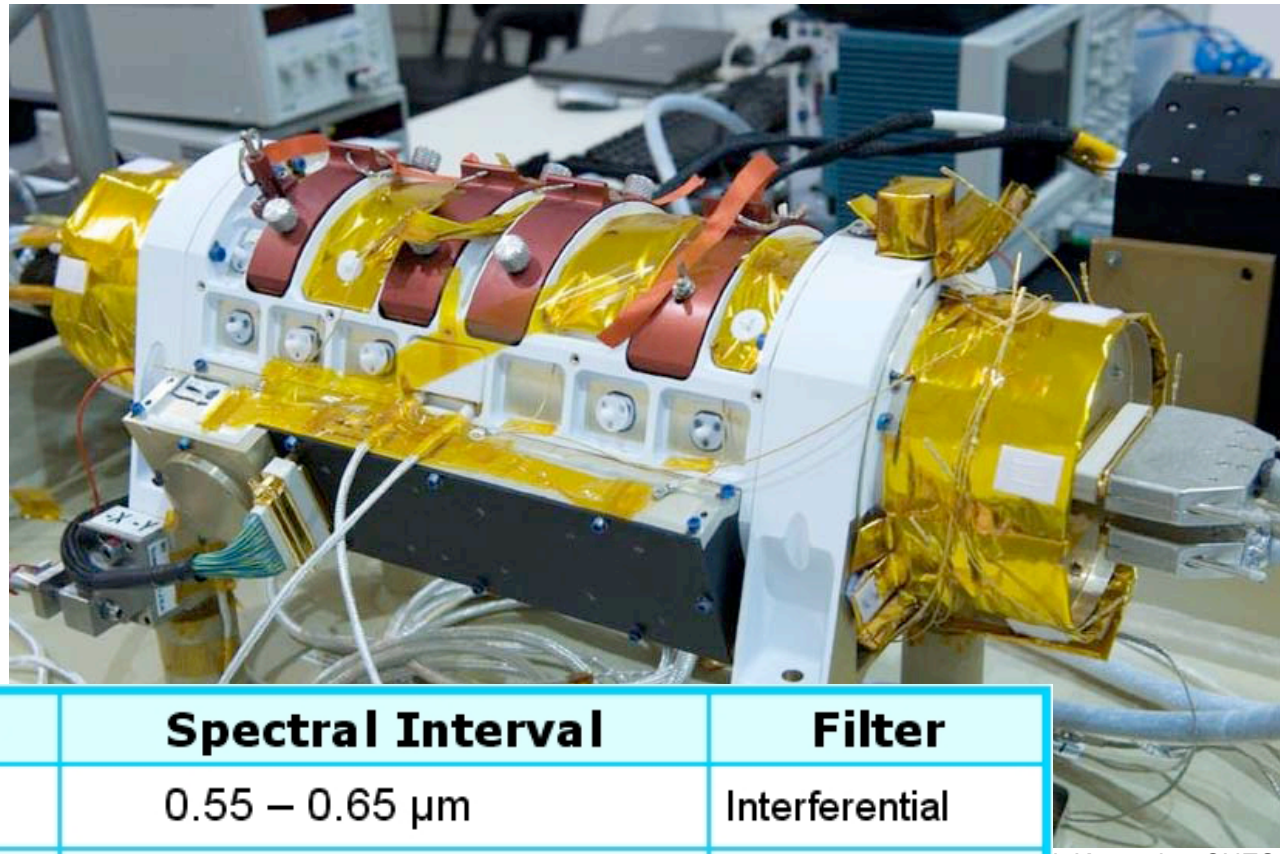
- **Radiative budget (complementary to CERES)**
- **Precipitation (enhanced sampling in the tropics)**
- **Water vapour (enhanced sampling in the tropics),**

The Megha-Tropiques mission
Payloads (1/2)

•**ScaRaB** : broad band instrument for inferring longwave and shortwage outgoing fluxes at the top of the atmosphere

•ScaRaB-3 on MT

•cross track scanning
•40 km resolution at nadir

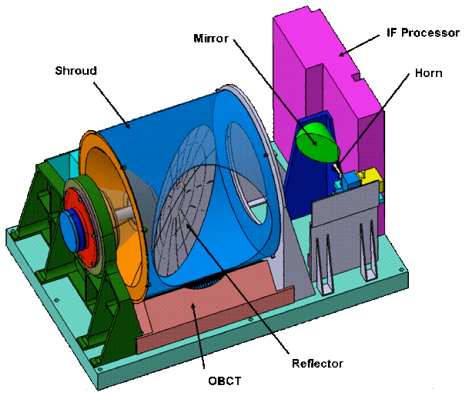


I. Karouche, CNES

Channel	Description	Spectral Interval	Filter
1	VIS (visible)	0.55 – 0.65 µm	Interferential
2	SW (or solar)	0.2 – 4 µm	Silice filter
3	T (total)	0.2 – 100 µm	No filter
4	IR (Infrared)	10.5 – 12.5 µm	Interferential

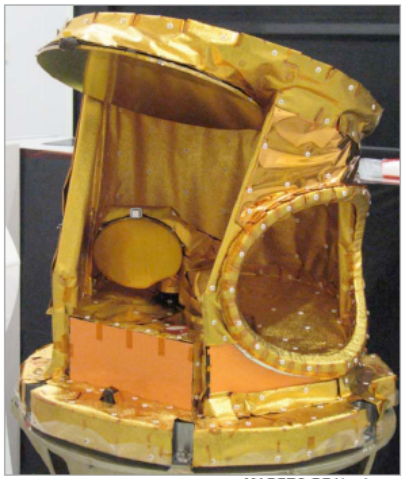
The Megha-Tropiques mission
Payloads (2/2)

SAPHIR : microwave sounder for water vapour sounding : 6 channels in the WV absoption band at 183.31 GHz. (cross track, 10 km)



Source: N. Karouche, CNES

MADRAS : microwave imager for precipitation : channels at 18, 23, 37, 89 and 157 GHz, H and V polarisations. (conical swath, <10 km to 40 km)


MARFEQ RF Hardware

GPS RO: water vapor profile …

GEOSTATIONARY DATA

- Cloud mask for the MW algo
- Quicklook for interpreting MT data
- Basic inputs for MCS tracking algorithm
- Basic inputs for Level 4 rainfall (radiation) products

The Megha-Tropiques mission

Orbit (1/2)

Megha-Tropiques

Orbite par rapport à la Terre

Phasage = [14; -1; 7] 97

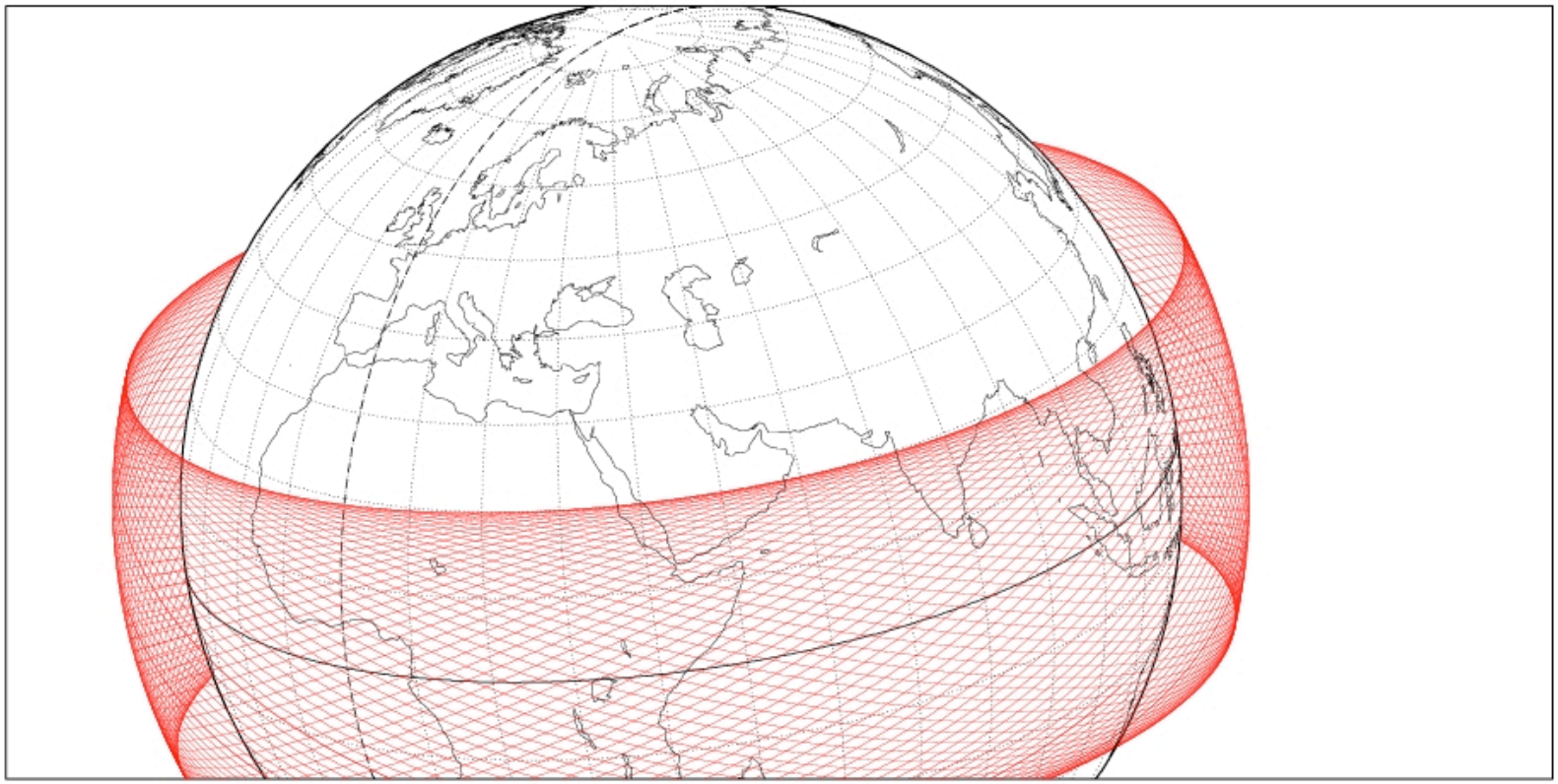
>>> Durée représentée : 7.00 jours

Altitude = 865.5 km a = 7243.678 km

Inclinaison = 20.00 °

Période = 101.93 min * Révol./j.=14.13

Décalage à l'équateur = 2892.0 km (26.0 °)



Projection : Orthographique CP: 20.0 ° N; 45.0 °E/CZ: 30.0 ° N; 60.0 ° E Noeud asc. : -180.00 ° [00:00 TSM]

Propriété : (sans) Aspect : Oblique

⊕ T.:Azimutal - Grille : 10° {4.2} [-90.0/ +70.0/ +45.0] [+8] EGM96

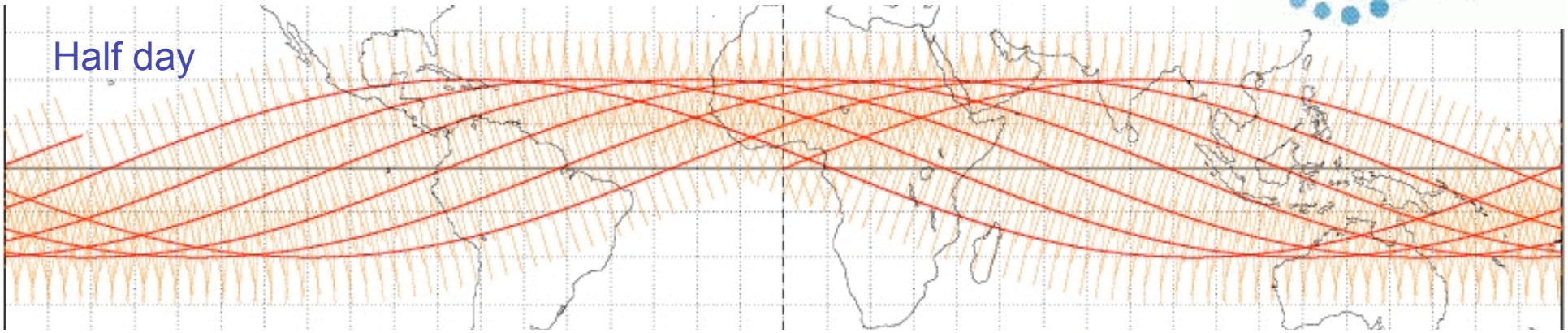
Ιξιων

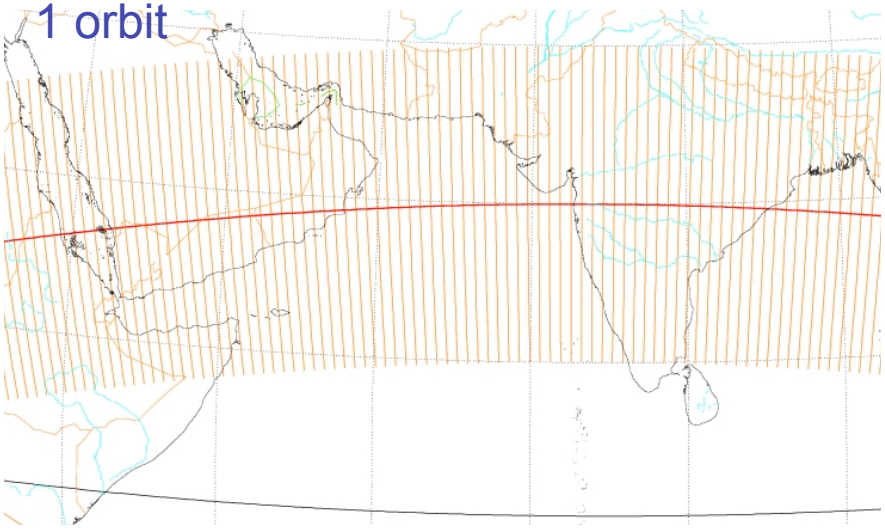
MC ★ LMD

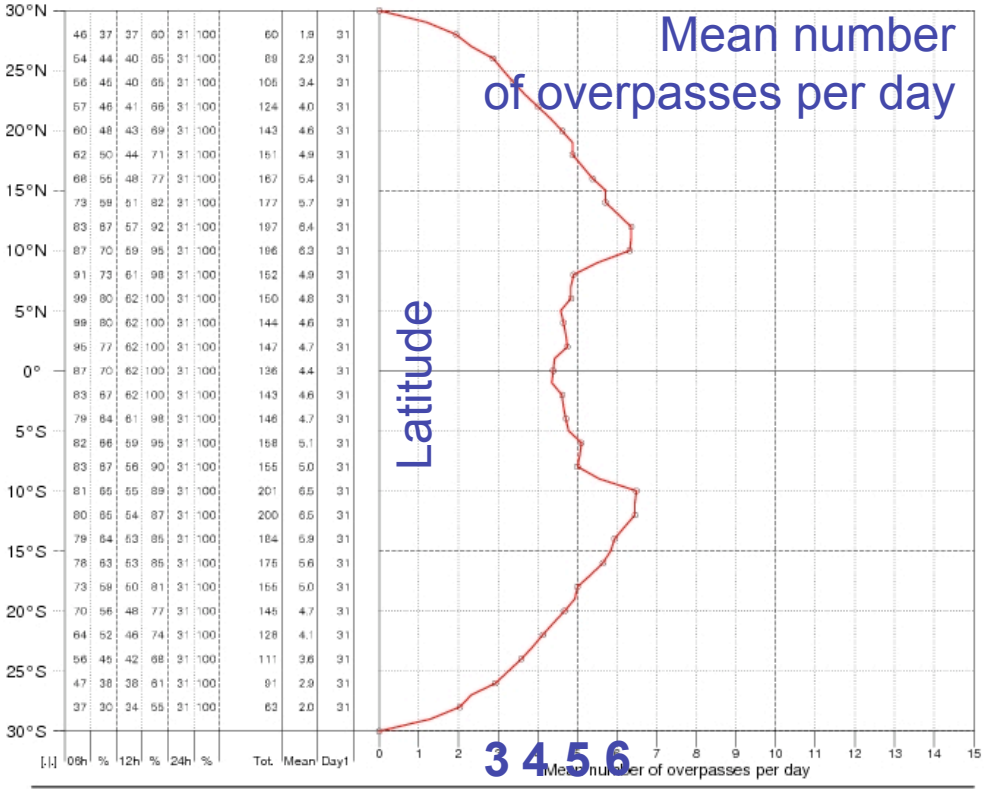
Ατλας

The Megha-Tropiques mission

Orbit (2/2)

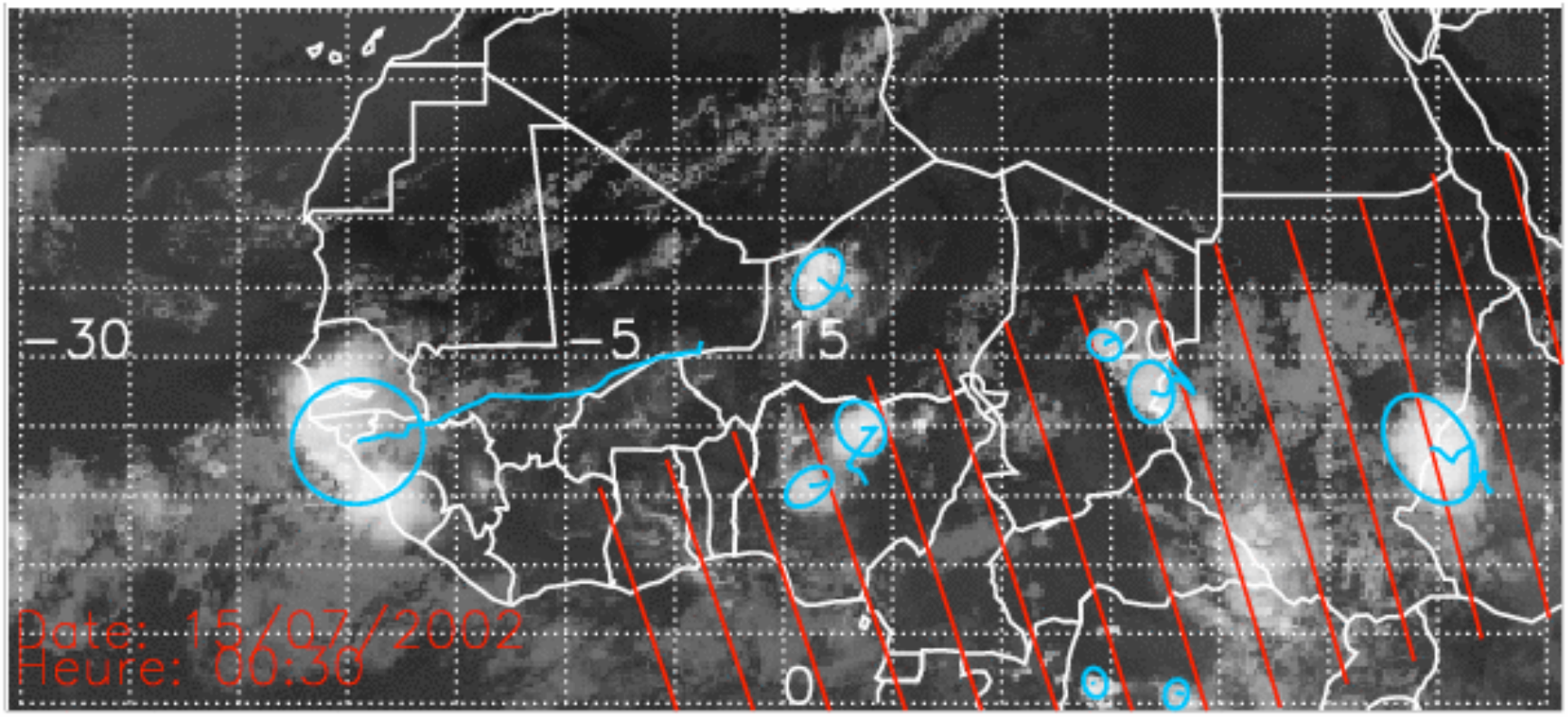






SCARAB sampling over 20°S-20°n
Min 4 per day
Max 6 per day

Life cycle of Mesoscale Convective Systems
Compositing with MT



The Megha-Tropiques mission

Eearth radiation budget measurement summary

Across scales:

from the tropical belt down to the MCS scale

Combination of the payloads:

WV sounding (SAPHIR) and OLR (Scarab) to study the greenhouse effect

Latent heat (MADRAS) and CRF (Scarab) to study the relative role of these two components of the atmospheric heating

Cloud information (GEO) and WV in the low levels (MADRAS) and TOA RB (ScaRaB) to constrain surface radiation budget estimates

ERB activities in the MT Team

Products developpements

Chomette, Raberanto, et al

ERB products Day 1

L3 regional monthly mean average TOA fluxes (SW+LW)

Mean accuracy of 5 Wm^{-2} (~20 Wm^{-2} for instantaneous fluxes)

Radiance to flux conversion with ADM (12 scene types)

Scarab ERBE Like algorithm (SEL)

L2 Instantaneous TOA fluxes (SW+LW)

Accuracy of 10 Wm^{-2} for instantaneous fluxes

CERES ADMs are considered as reference

Table 2, Loeb, JAM, 2003

	Estimated regional (1°) instantaneous SW TOA flux error ($W.m^{-2}$) – All sky
ANN	10.8
ERBE-like	24.4

Scarab Artificial Neural Network algorithm (SANN)

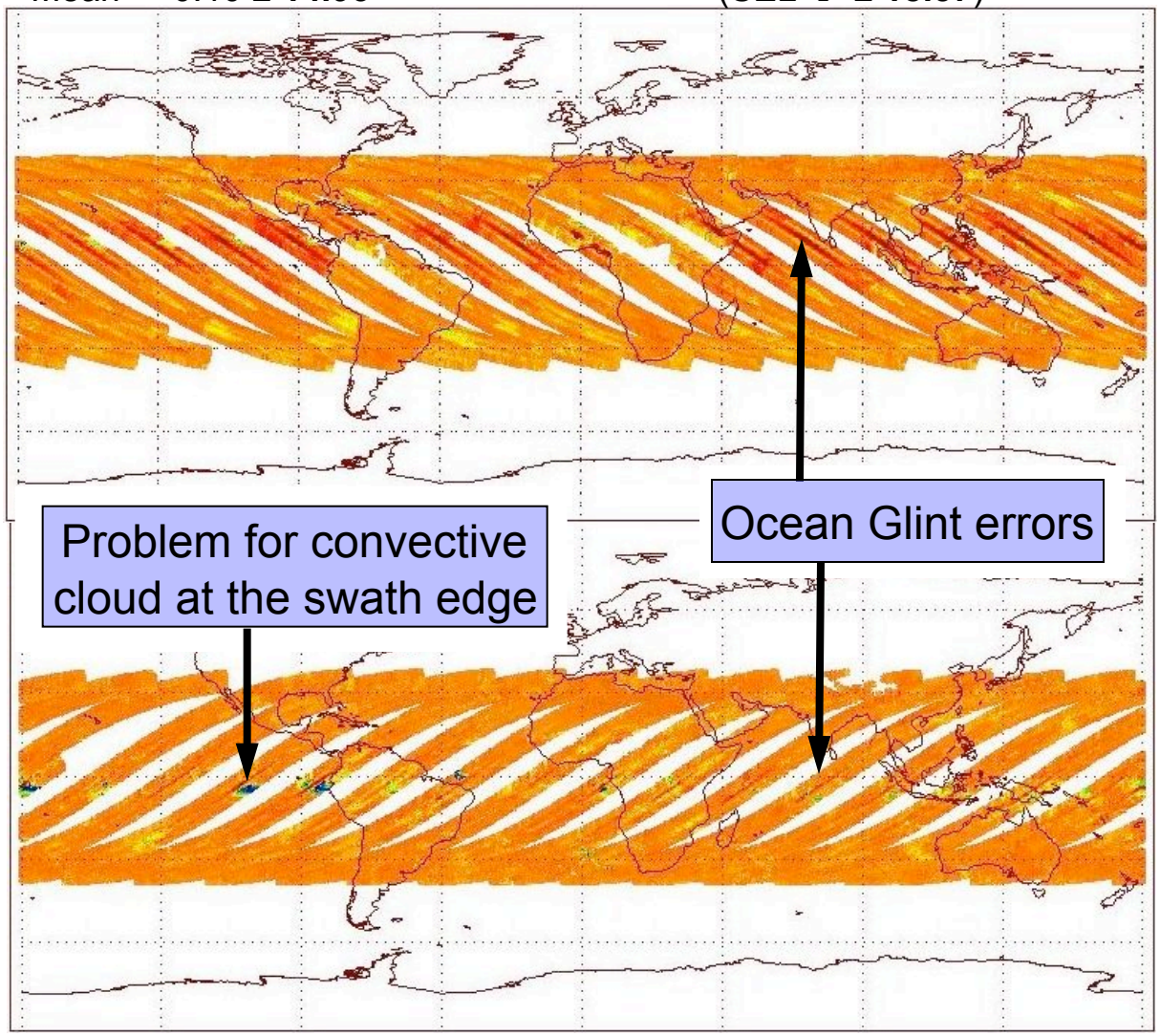
ERB products Day 2

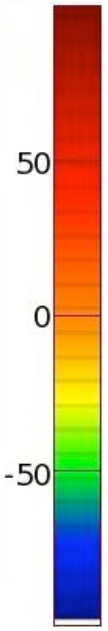
L2/L3 surface radiation budget

ERB activities in the MT Team

Products developpements

(SANN **Broadband** – CERES) **SW** Flux (W.m^{-2}) ; 08/29/1998
Mean = -0.10 ± **14.93** (SEL ➔ ± **18.57**)





With Broad bands

50% error reduction with respect to SEL (except for ocean/glint scenes where it's worse)

With Narrow bands

40% error reduction with respect to SANN broadband ➔ Essentially due to improvements for ocean/glint scenes

(SANN **Narrowband** – CERES) SW Flux (W.m^{-2}) ; 03/20/1998 Mean = -1.15 ± **9.60**

ERB activities in the MT Team

Clear sky greenhouse effect activities

Guzman, Picon et al

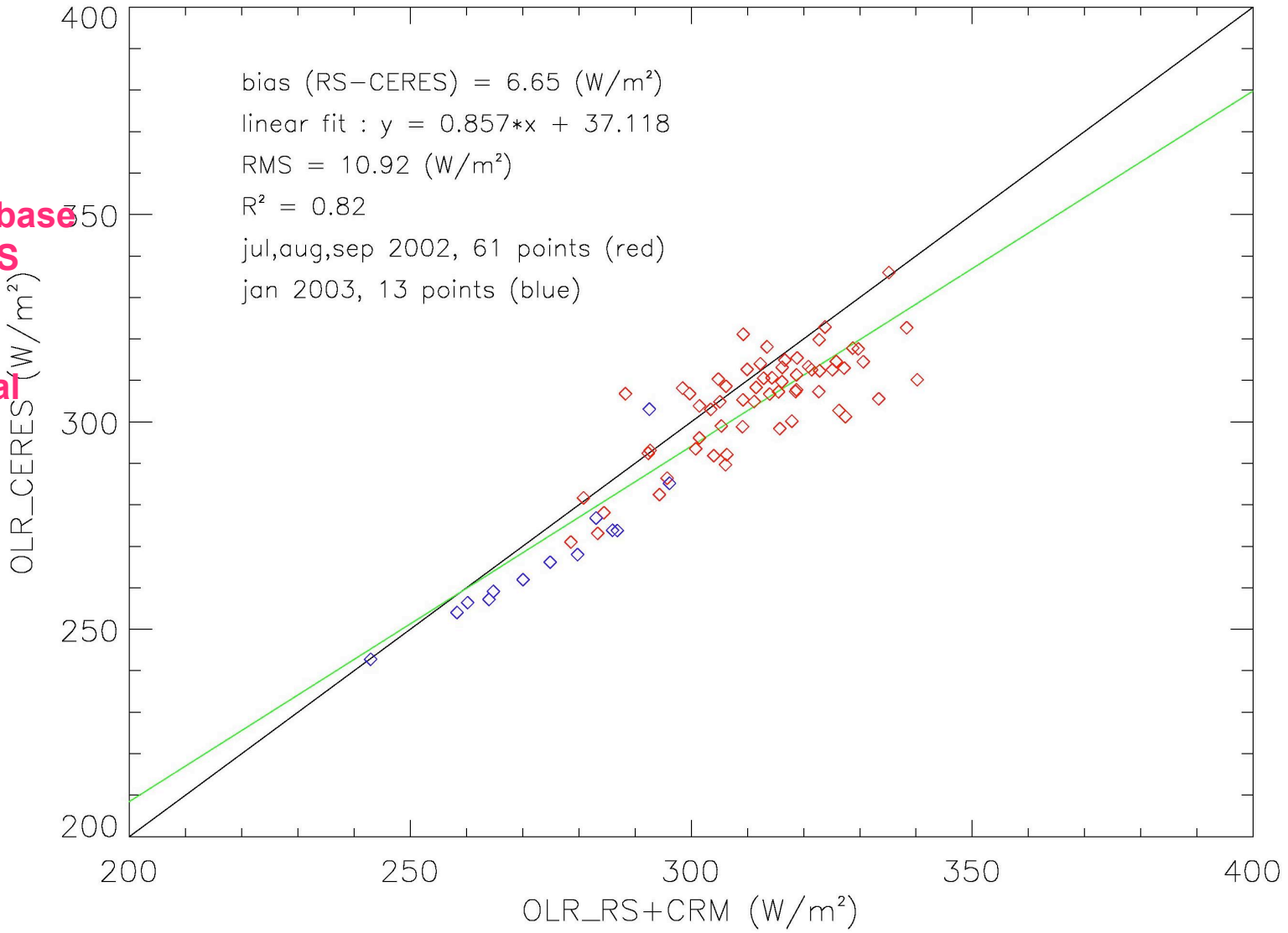
Preliminary results

-CERES AQUA
-HSB

Buidling a
Collocated database
RS (nite)+CERES

Building
HSB WV retrieval
+CERES

Radiosondes
+CRM

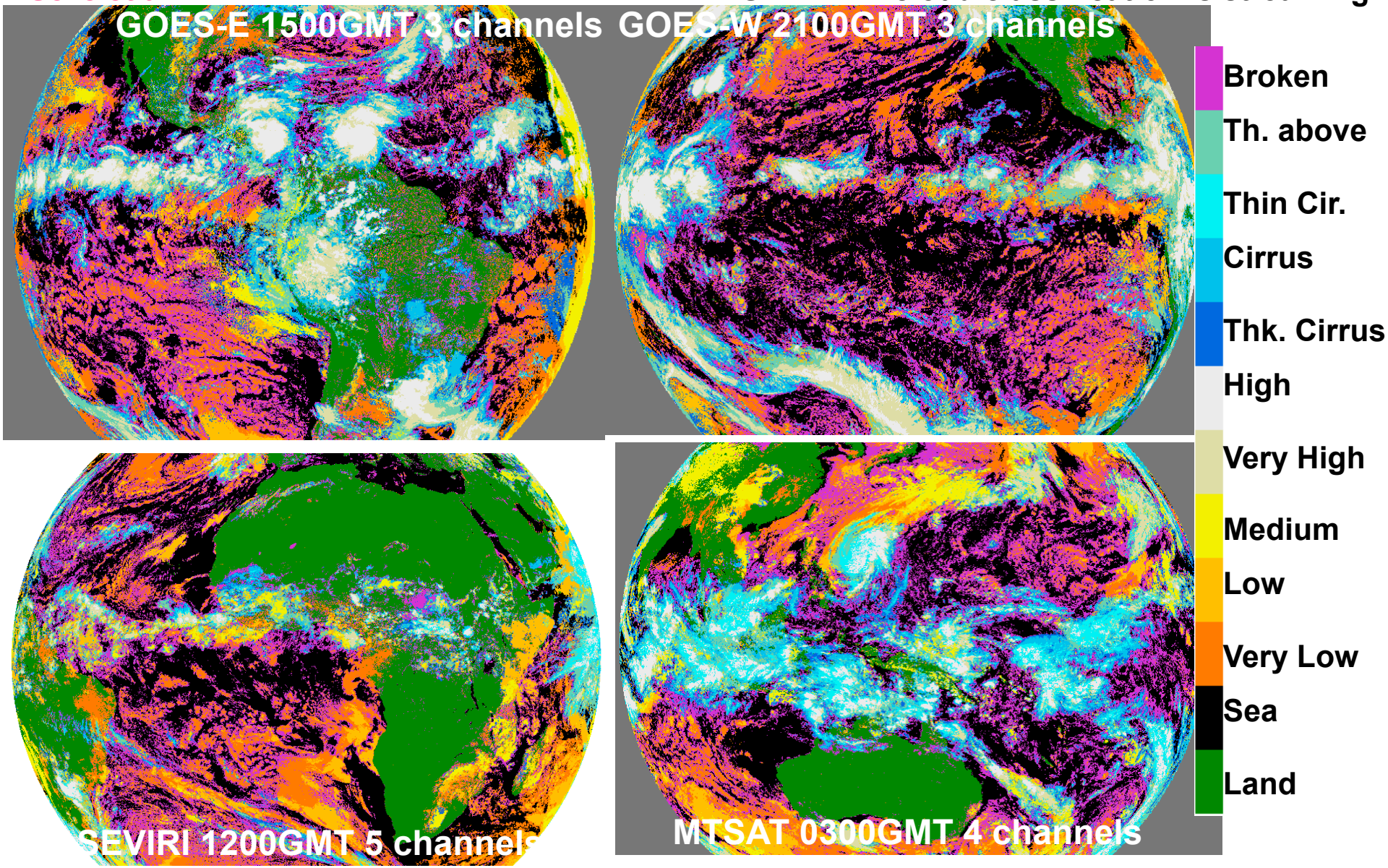


ERB activities in the MT Team

GEO cloud activities

Sèze et al

SAF NWC cloud classification is streaming



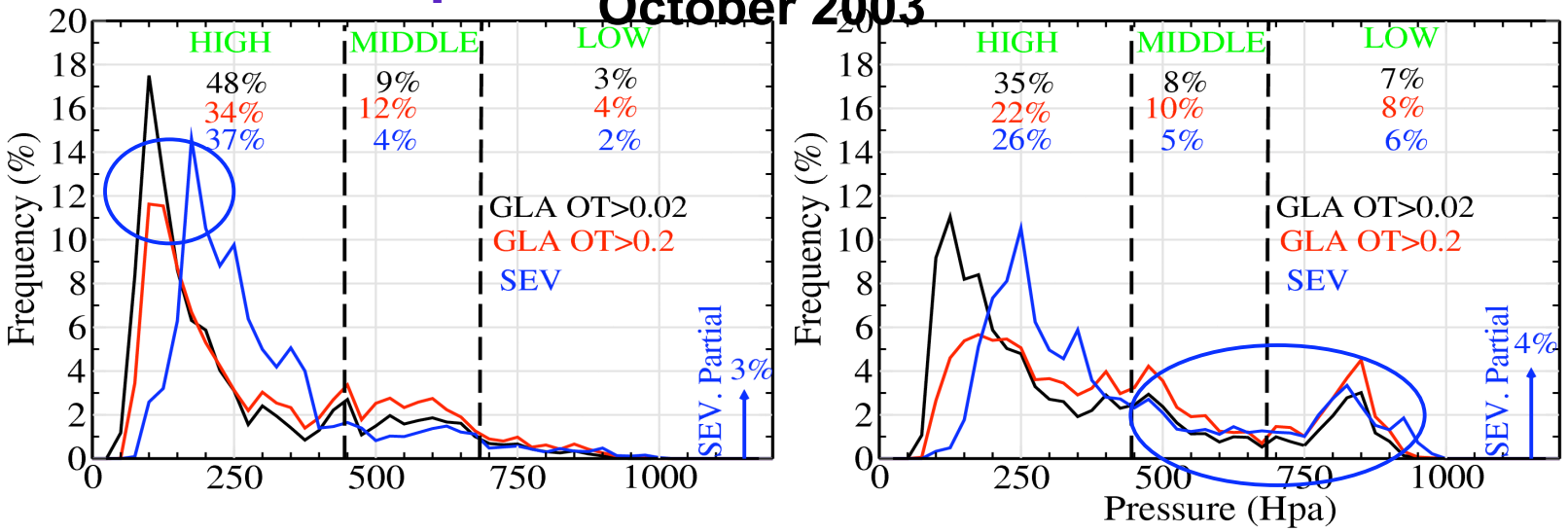
ERB activities in the MT Team

GEO cloud activities cloud top pressure over land

Sèze et al

GLAS >0.02
GLAS >0.2
SEVIRI

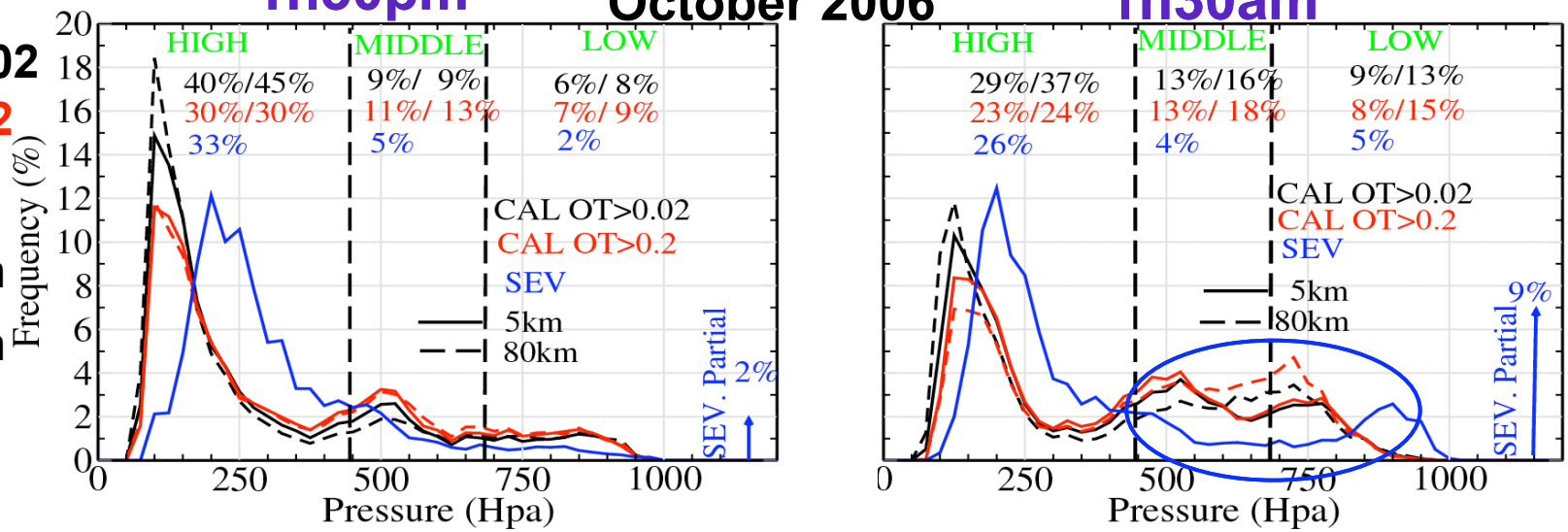
7h30pm — October 2003 — 7h30am



CALIOP >0.02
CALIOP >0.2
SEVIRI

5km
80km

1h30pm — October 2006 — 1h30am



Distributions normalized by the number of sample in the distribution.

The CAL/VAL Plan

- Radiometric quality check before and after launch
  - spectral characterization
  - gain determination
  - DCC method to validate SW radiances

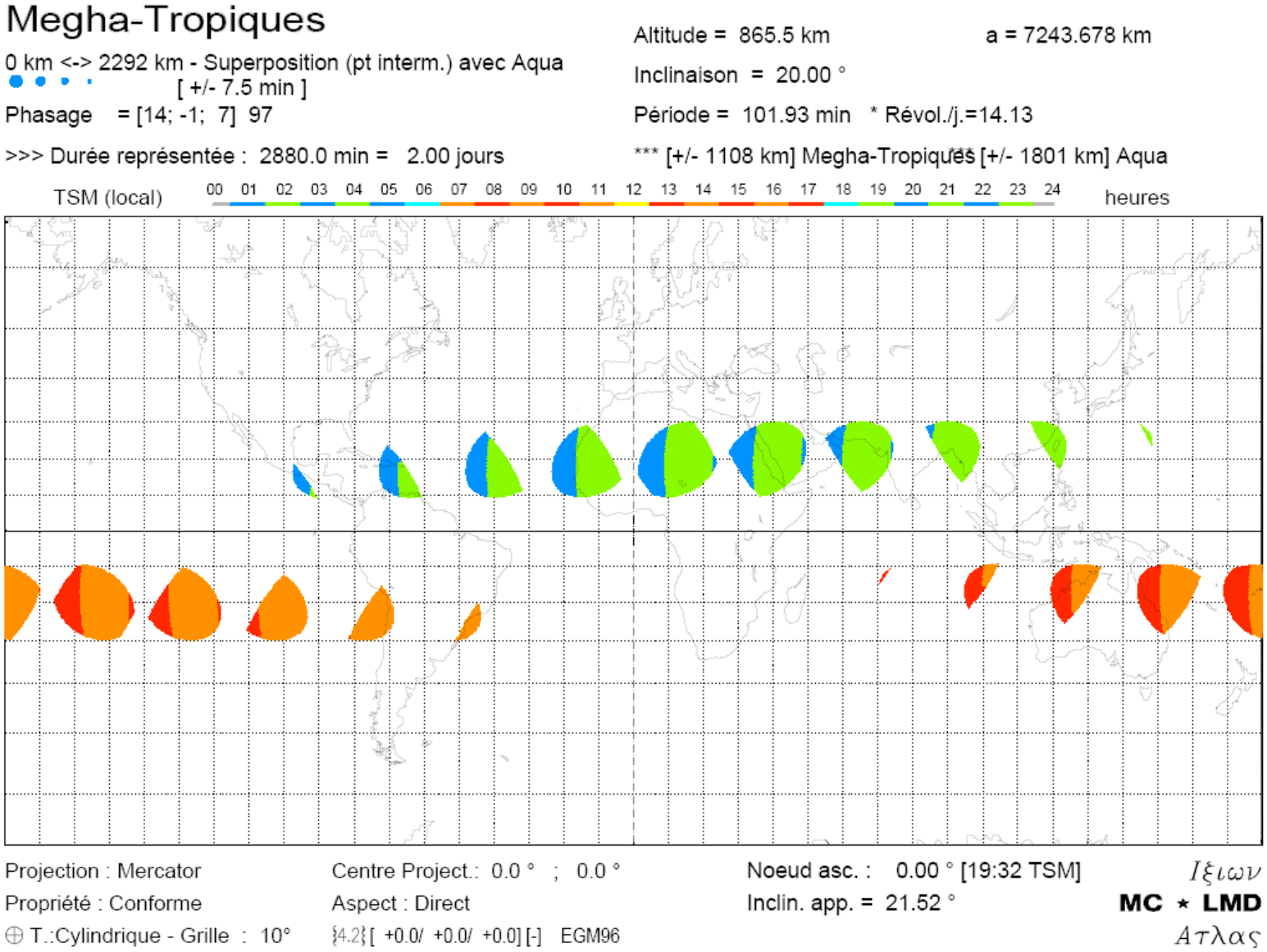
- Vicarious calibration (indirect methods)
  -With terrestrial targets with known reflectance (desert, thick clouds)

- Internal consistency checks
  - Independence of TOA fluxes on the viewing geometry
  - comparison with historical data

- Comparison with other ERB instruments
  - CERES
  - GERB

Validation using CERES one example

Example with CERES (2 days), ±5 mn, no viewing angular conditions



Megha-Tropiques ISRO-CNES Joint IAO

International Announcement of Opportunity (IAO)

Proposals evaluated by a Joint Indo-French committee

It should be noted that this AO does not fund the 'projects', but only ensures that the selected Principal Investigators (PI) are provided with Relevant data sets at no cost.

- Development of retrieval algorithms and Cal/Val experiments
- Basic research on the physics of the Tropical Climate
- Synergistic studies using multi-sensor/multi-satellite data to understand convective processes
- Techniques development for assimilation of MT radiances or derived geophysical parameters in numerical models

MEGHA-TROPIQUES: Announcement of Opportunity

1.0 DESCRIPTION OF THE OPPORTUNITY

1.1 Overview of the Objectives

The common objective between India and France to understand the role of tropics in global weather and life has helped formation of science missions like Megha-Tropiques and SARAL as joint collaborative programs. The main purpose of these missions is to develop space-borne experimental techniques and carryout systematic observations and research to meet the defined scientific objectives.

MEGHA-TROPIQUES (MT) is an ISRO-CNES joint collaborative project. The objective of the project is to study the convective systems and their influence on tropical weather and climate. The MT satellite payloads are Microwave Analysis and Detection of Rain and Atmospheric Structures (MADRAS), a millimeter wave humidity profiler, SAPHIR and an optical-IR radiometer for radiation budget (ScaRAB). Megha-Tropiques is scheduled to be launched onboard Polar Satellite Launch Vehicle (PSLV) from Sriharikota, India. The data from the satellite is likely to be made available to the global scientific community after necessary post-launch sensor characterization, which is expected to be completed within 6-9 months from the launch.

This Announcement of Opportunity (AO) is open to global scientific community for submitting research proposals towards utilization of data from MT Payloads in the following broad categories:

- Development of retrieval algorithms and Cal/Val experiments
- Basic research on the physics of the Tropical Climate
- Synergistic studies using multi-sensor/multi-satellite data to understand convective processes
- Techniques development for assimilation of MT radiances or derived geo-physical parameters in numerical models

It should be noted that this AO does not fund the 'projects', but only ensures that the selected Principal Investigators (PI) are provided with relevant data sets at no cost.

1.2 Who can submit a Proposal?

Proposals could be submitted by individuals or a group of scientists, academicians and research scholars belonging to recognised institutions, universities, government and non-government organisations. The proposals must be supported by the Investigators' Institution, with appropriate assurance for providing necessary facilities for carrying out the AO projects.

2.0 OVERVIEW OF MEGHA-TROPIQUES MISSION

Opening of the call: **November 2009 end**

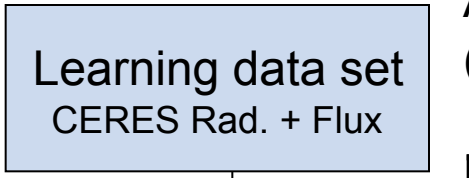
http://www.cnes.fr
http://www.isro.in
http://meghatropiques.ipsl.polytechnique.fr

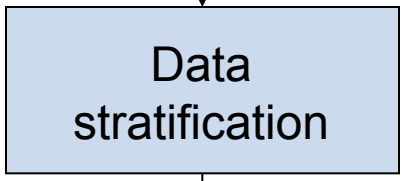
Thank you for your attention

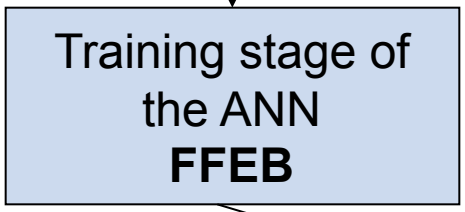
http://megha-tropiques.ipsl.polytechnique.fr

- Back up slides

ScaRaB Artificial Neural Network







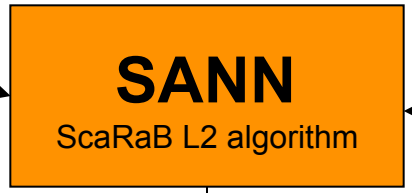
ANN learning with TRMM data (10 km spatial resolution at nadir)
(orbit near to MT orbit – 35° inclination compared to 20°)

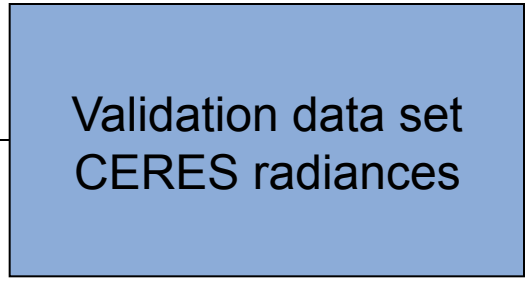
Variable	Bins #	Bin width
VZA	7	10°
SZA	9	10°
RAZ	9	20°
LWR	15	10 $W.m^{-2}sr^{-1}$
SWR	30	10 $W.m^{-2}sr^{-1}$

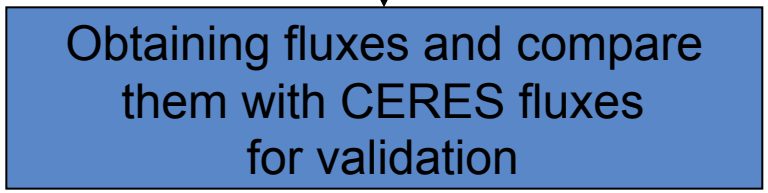
Exemple : one **SW** case

Stratification goal : reduce the size of the learning data set by keeping its statistical representation.
7x9x9x15x30=255150 bins

6 scene types
no-glint ocean, glint, medium-high and low medium, tree-shrub, dark and bright desert







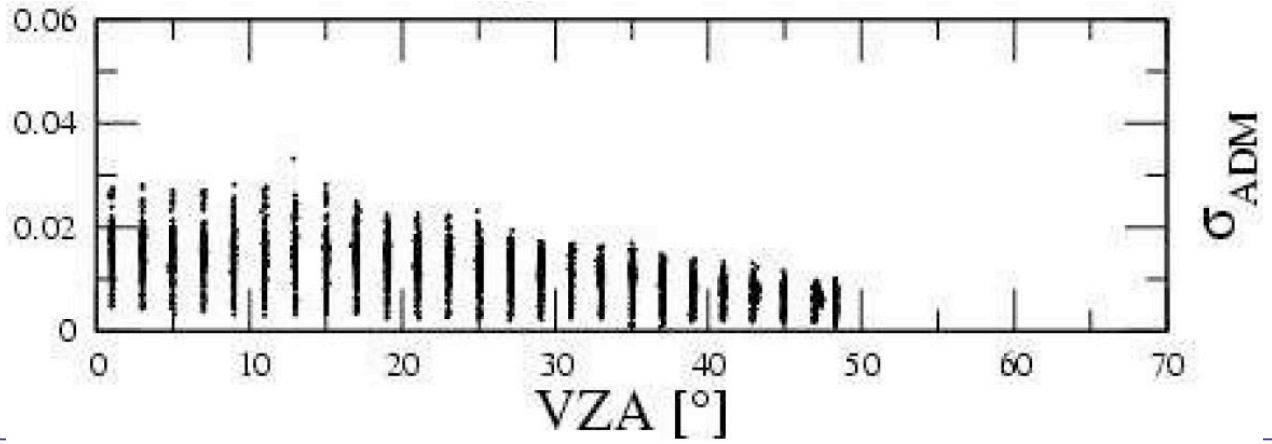
ScaRaB Artificial Neural Network (SANN) LW results

Leaning data	Input
RAP 68 days 01/98 – 08/98	VZA, PW, LLw, Lsw
XT 16 days 07/98 – 08/98	VZA, Lir, Llw, Lsw
XT 16 days 07/98 – 08/98	VZA, PsAbs, Lir
XT 16 days 07/98 – 08/98	VZA, PsAbs

*compared to the intrinsic model error 2.4 Wm^{-2}

Version	Error Wm^{-2}	Rms error reduction Wm^{-2}
ERBE	+2.94 ± 3.15*	4.30
ANNa	-0.60 ± 2.89*	2.95 (30%)
ANNc	-1.20 ± 2.99*	3.22 (25%)

For each bin, the standard deviation of the ADM~0.01 (corresponding to 2.4 Wm-2 for a global LW means of 240 Wm-2) which marks the intrinsic accuracy of the model.



The products

ScaRaB validation, one example

ScaRaB/MT & GERB/MSG

- MT Launch: 2010, life-time 3 years
- GERB: continuous program (GERB 3 and 4 until 2015… and more)
- Common spatial coverage (30°N-30°S ➔MT limits
  50°W-50°E ➔MSG limits)
- Similar footprints: ~40 km

Validation

ScaRaB validation, one example

Possible ScaRaB/GERB Comparisons

- Radiances comparisons of simultaneous co-located and co-angular observations

SW radiances

Co-angular (θ_{zenith} ±5° & $\theta_{azimuth}$ ±10°)

Simultaneous (ΔT ± 7.5 mn)

LW radiances

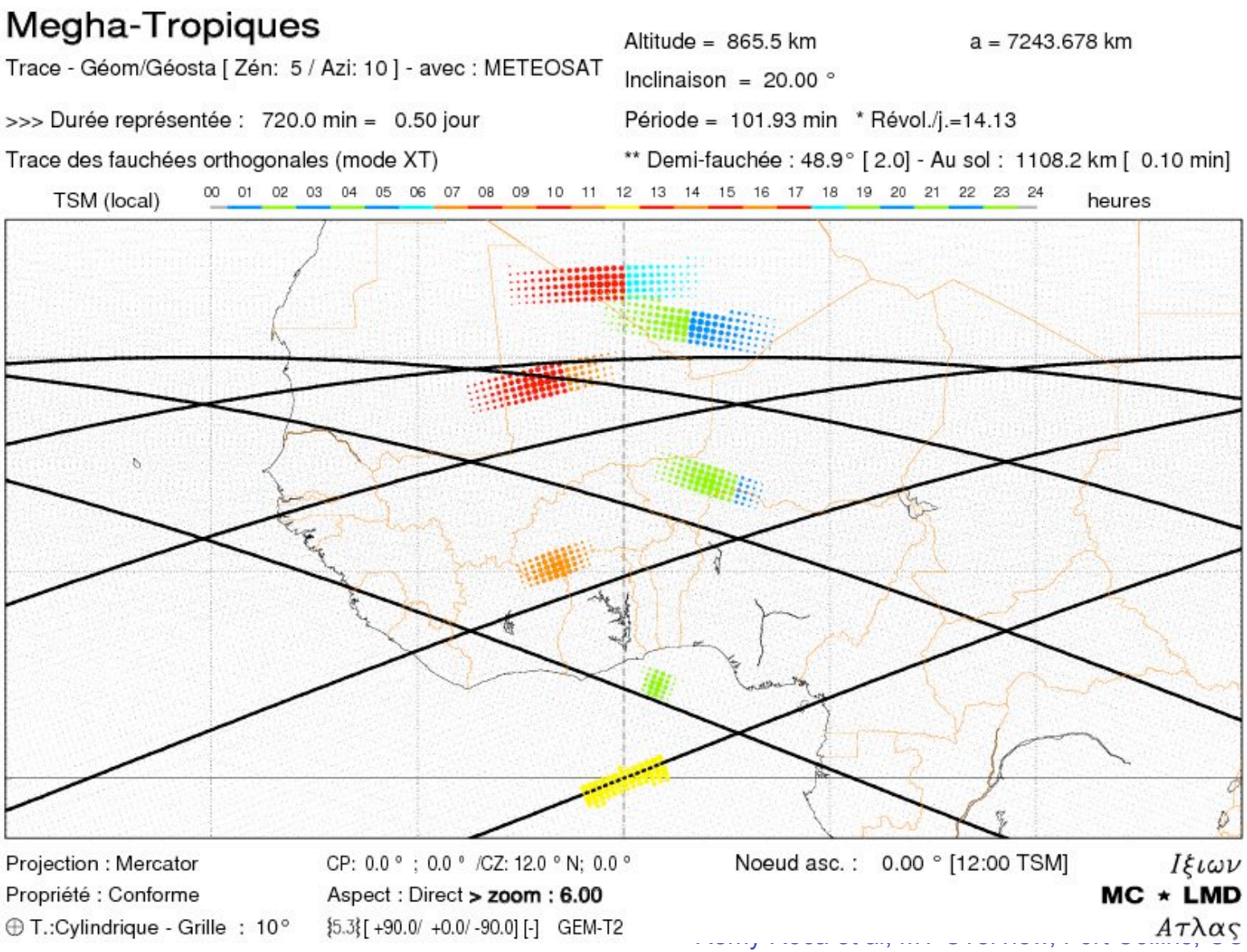
Same as SW without the $\theta_{azimuth}$ constraint

- More comparisons !
  - Fluxes of simultaneous co-located observations
  - Monthly means fluxes of the common tropical area

Validation

ScaRaB validation, one example

ScaRaB/GERB Simultaneous SW co-location



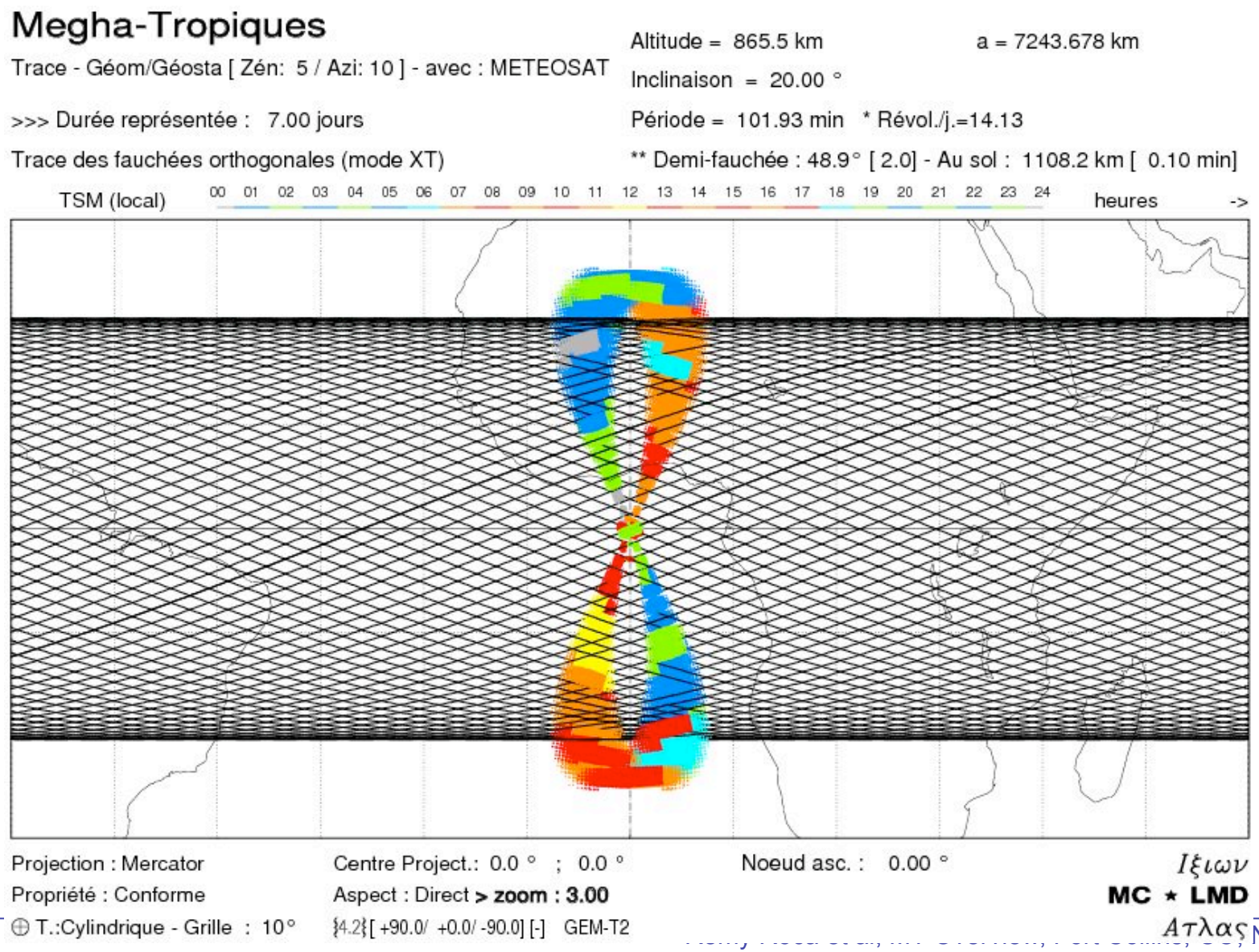
θ_{zenith} ±5°

$\theta_{azimuth}$ ±10°

Validation

ScaRaB validation, one example

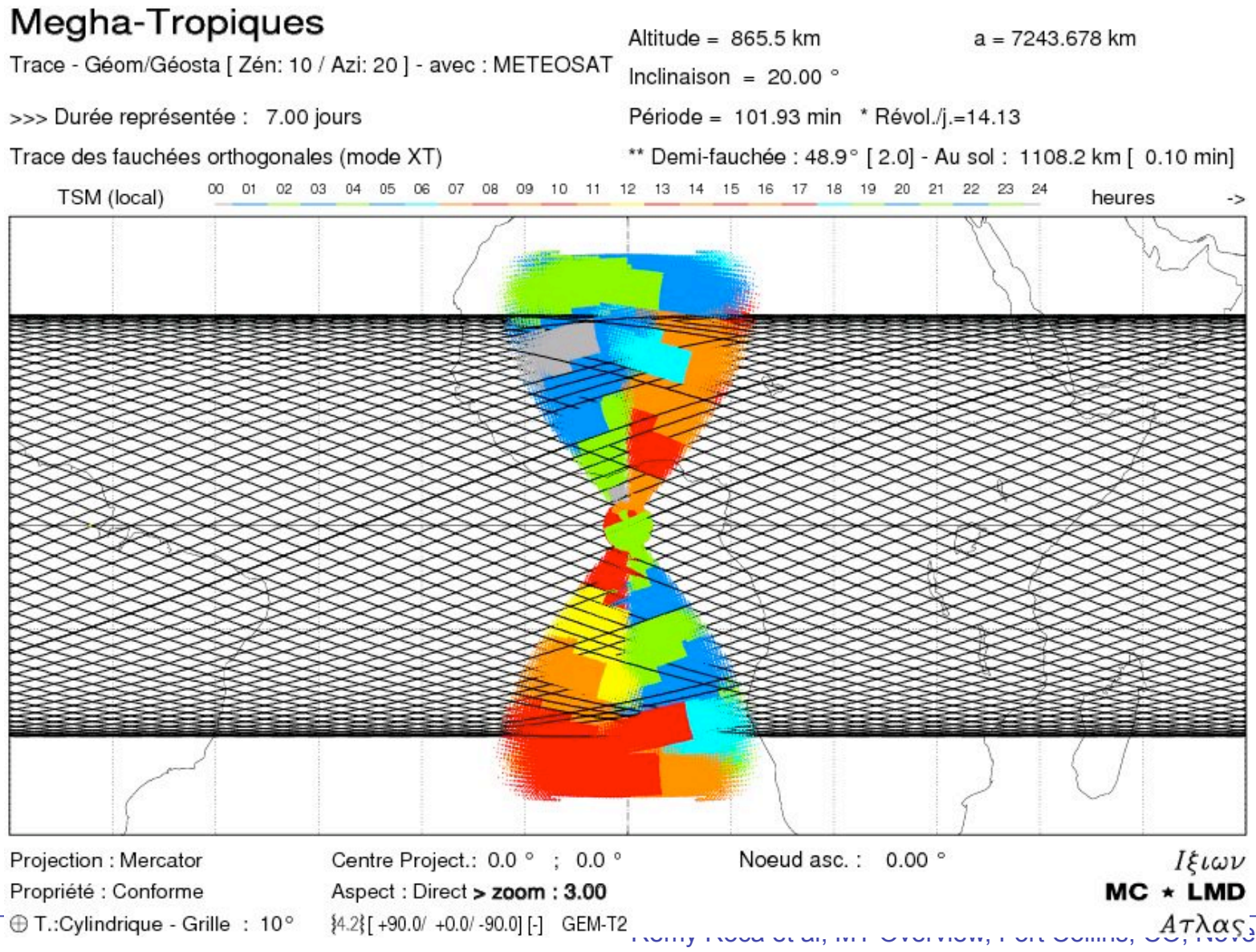
For 7 days (SW) - θ_{zenith} ±5° - $\theta_{azimuth}$ ±10°



Validation

ScaRaB validation, one example

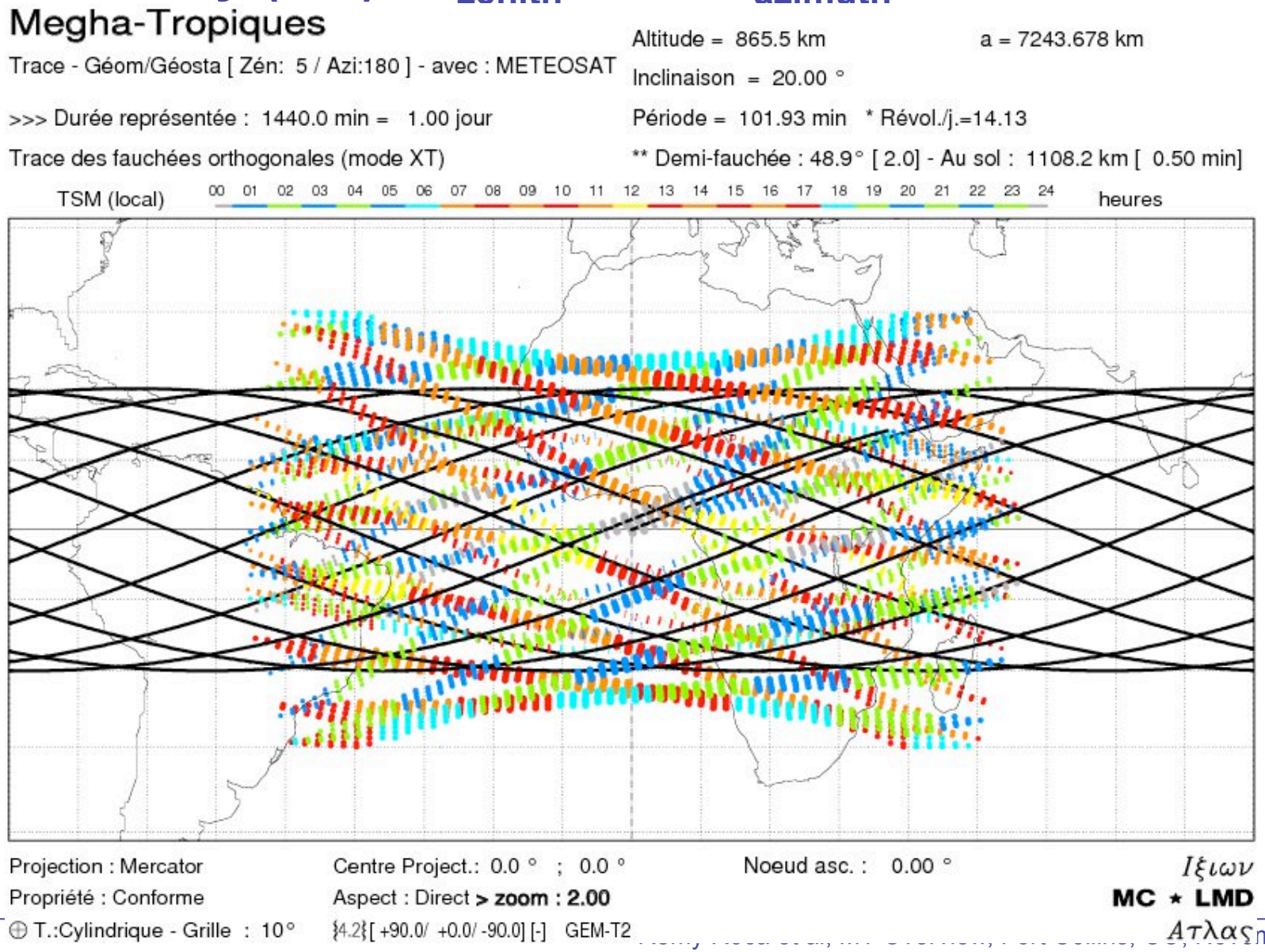
For 7 days (SW) - θ_{zenith} ±10° - $\theta_{azimuth}$ ±20° :



Validation

ScaRaB validation, one example

For 1 day (LW) - θ_{zenith} ±5° - $\theta_{azimuth}$ no constraint



Validation

Scene type	all	all but ocean/glint	ocean/ glint	ocean/ no glint	LMTS/ land	MHTS/ land	bright desert	dark desert
ANN-BB-RAP (1st period)	-4.68 ±15.08	-3.05 ±9.57	-11.24 ±24.35	-4.28 ±9.19	-0.32 ±10.29	-0.47 ±9.96	-1.50 ±6.49	-0.29 ±9.76
ANN-BB-RAP (2nd period)	-3.06 ±13.58	-1.90 ±8.85	-8.30 ±23.02	-2.91 ±8.33	0.89 ±10.23	0.27 ±9.39	-0.50 ±5.96	-0.28 ±9.14
ANN-BB-XT (1st period)	-1.42 ±10.62	-1.28 ±8.12	-2.02 ±16.64	-1.08 ±7.71	-0.53 ±9.04	-0.98 ±8.78	0.77 ±6.06	0.04 ±8.91
ANN-BB-XT (2nd period)	-0.39 ±9.30	-0.16 ±7.22	-1.42 ±14.72	-0.23 ±6.93	0.08 ±8.54	-0.14 ±7.82	-0.24 ±4.83	-0.24 ±7.15
ANN-NB-XT (1st period)	-1.15 ±9.39	-1.10 ±7.48	-1.40 ±14.33	-1.61 ±6.51	-0.36 ±9.14	-0.77 ±10.13	+1.57 ±6.37	+1.05 ±8.02
ANN-NB-XT (2nd period)	-0.24 ±8.29	+0.01 ±6.78	-1.52 ±12.39	-0.05 ±6.06	+0.07 ±8.33	-0.13 ±9.05	+0.06 ±5.06	+0.27 ±6.88

Learning period ➔ 2nd period - Validation period ➔ 1st period

Average SW flux errors (bias±standard deviation) in [Wm-2] of the ANN ADM (ANN-BB-RAP in green ; ANN-BB-XT in blue & ANN-NB-XT in yellow).